



**Embedded Linux
Conference**
Europe



OpenIoT Summit
Europe

Grabbing audio and video on a farm

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Agenda

What is board farm for?

Typical setups

HDMI Pi as PoC

Future work

Summary

Q & A



What is board farm for?

Automated testing systems

- **Manual testing is very time consuming**
- **It does not scale**
- **Fortunately most of tests can be automated**
- **There are two options to run them**
 - Emulator
 - Physical board

HW sharing/hiding

- **Some development targets have to be kept secret**
- **Having as many boards as developers is often not feasible**
- **This makes the board a shared resource**
- **But doing this in traditional way is at least annoying**

Remote access to HW

- **Samsung (like many others) is scattered around the world**
- **Not every board is available in every office (or home)**
- **Sometimes issues are very hardware dependent**
- **Buying or shipping the board may often take days if not weeks**

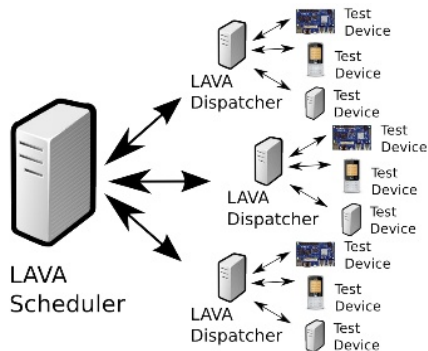
Board Farm challenges

- **Every board is unique like a snow flake**
- **It's hard to provide unified access to it (but possible)**
- **Maintenance**
- **Stability**
- **Scalability**



Typical setups

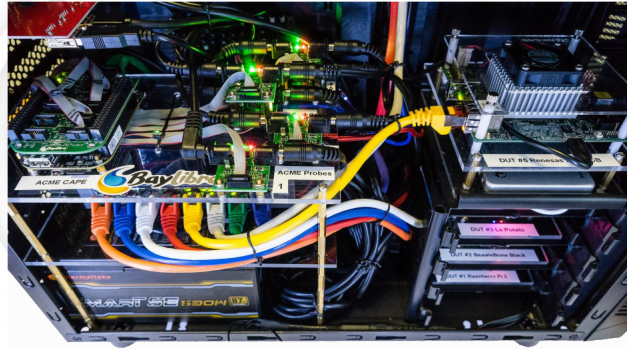
- **Linaro Automated Validation Architecture**
- **yaml job description**
- **Board interfaces**
 - Power relay
 - Serial
 - USB/Ethernet
- **Typical test consists of**
 - Downloading image
 - Flashing it to the DUT
 - Booting
 - Running test script
 - Collecting results



Source: [10]

Lab in a box

- PC case + PDU
- PC [(M), (D)]
- ACME
- Serials
- USB hub/controller
- Ethernet switch



Source: [9]

SLAV

Test
manager



WELES

Farm
manager

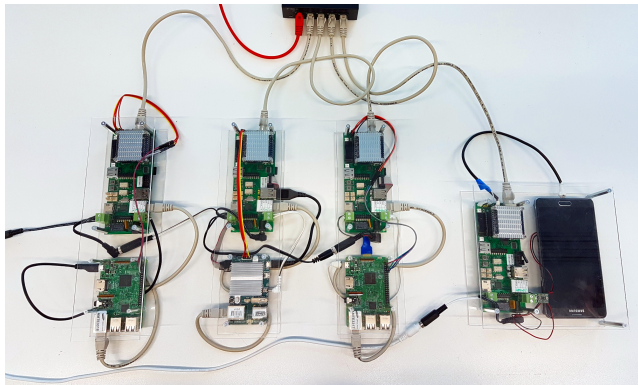


BORUTA

Board
controller



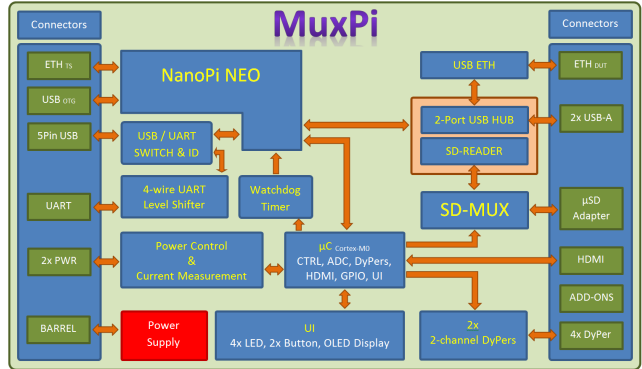
MuxPI



<https://github.com/SamsungSLAV>

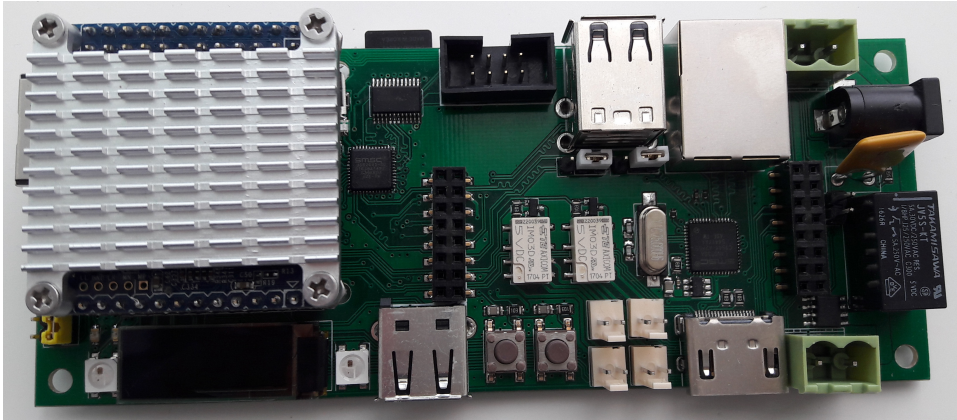
MuxPi

- Power Control
- SD-Mux
- DyPer
- Serial
- USB/Serial switch
- Power measurement
- Display
- 2 RGB diodes
- Extendability
- EDID injector



Source: [6]

MuxPi



EDID injector & screen shooter

- In order to identify the display EDID is required
- Without it you cannot make a screenshot
- Fortunately it can be injected via I2C



HDMIPI as PoC

Why not dedicated HW?

- There are HDMI grabbers available on the market
- But they cost around **\$300**
- And we need tens of those devices not just one
- And still you need to somehow stream the video over the network
- Most of them require USB 3.0
- Many of them cause high CPU usage

Lenkeng LKV373a HDMI Extender

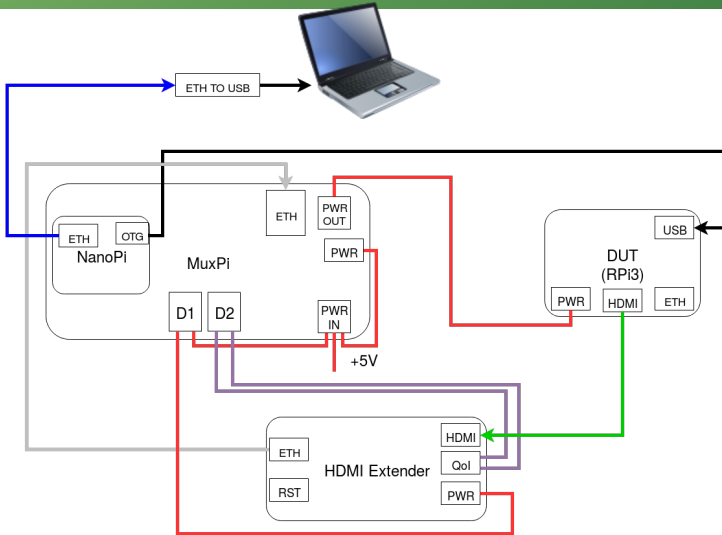
- **HDMI to Ethernet RX/TX**
- **HDMI Video and Audio converted to MPEG stream**
- **Streaming using multicast UDP**
- **A lot of investigation on this by danman[1]**
- **Idea shared during FOSDEM2018[3] by Joonas Lahtinen from Intel**
- **Cost?**

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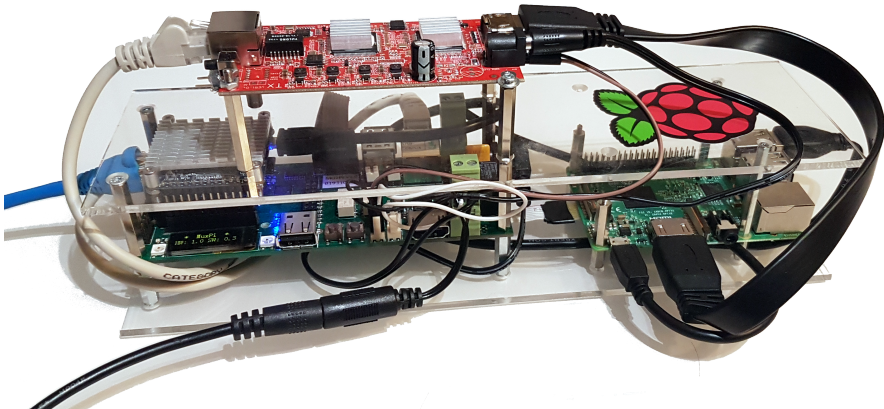
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\$30

Wiring



Wiring



Audio and Video - intro

- **LKV streams MPEG stream using UDP multicast**
- **Default IP: *192.168.1.238***
- **Default multicast group: *239.255.42.42:5004***
- **Stream can be captured using VLC, ffmpeg and many others**
- **VLC params really matter**
- **VLC version matters even more**
- **NanoPi kernel version also matters**

Audio and Video - solution

- LKV is connected to USB network card in MuxPi
- NanoPi has to reroute the stream and at least change the SRC
- **Solution #1:**

```
# socat UDP-RECV:5004,ip-add-membership=239.255.42.42:192.168.1.1 \  
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Issues: High CPU load + high delay

- **Solution #2:**

```
# smcroute -d
# smcroute -a eth1 192.168.1.238 239.255.42.42 eth0
# iptables -t nat -A POSTROUTING -p udp -d 239.255.42.42 \
        -j SNAT --to-source 192.168.0.13
# conntrack -F
```

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```

Issue: Unable to change destination (anyone?)

Audio and Video - versions

- **VLC version used: v3.0.3**
- **Params:**
 - Network caching: 200
 - Clock jitter: 0
- **NanoPi kernel: 4.11.2-github.com-friendlyarm-linux-43baabc1f+**
- **smcroute: 2.0.0 build 150506**

HID - Human Interface Device

- **NanoPi is equipped with UDC**
- **So it can act as any USB device[8]**
- **Linux Kernel provides HID protocol implementation**
- **So we can easily act as a Keyboard and Mouse device**

```
cd /sys/kernel/config/usb_gadget
mkdir g1
cd g1

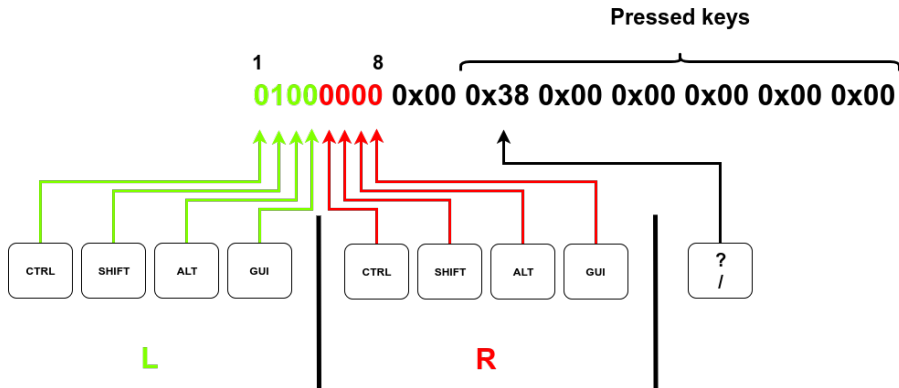
echo 0x1a2c > idVendor
echo 0x0c21 > idProduct

mkdir strings/0x409
echo "MuxPi" > strings/0x409/manufacturer
echo "Kbd+Touch" > strings/0x409/product
echo "001" > strings/0x409/serialnumber
mkdir functions/hid.kbd
cd functions/hid.kbd
echo 0 > subclass
echo 1 > protocol
echo 8 > report_length
cat /root/usb_hid/kbd_desc > report_desc
cd -
mkdir functions/hid.touch
cd functions/hid.touch
echo 0 > subclass
echo 0 > protocol
echo 8 > report_length
cat /root/usb_hid/touch_desc > report_desc
cd -
mkdir configs/c.1
ln -s functions/hid.kbd configs/c.1
ln -s functions/hid.touch configs/c.1

echo `ls -l /sys/class/udc` > UDC
```

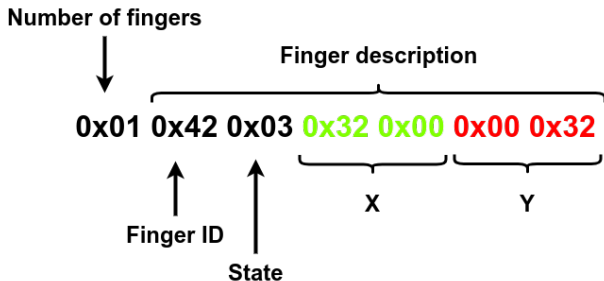
Keyboard

- Write report descriptors to `/dev/hidg0`
- Report descriptor format:



Mouse

- Write report descriptors to `/dev/hidg1`
- Not really a mouse but a touchscreen
- Some math to calculate the position
- Report descriptor format:



Putting all into one app

- App written using Qt library
- QSsh for commands execution
- QSsh for HID fwd
- QVlc for display

<https://github.com/kopasiak/muxpi>

DEMO

Issues

- **Lack of mouse tracking**
- **In-kernel multicast to unicast conversion**
- **Delay**
- **Video quality**
- **Stability**



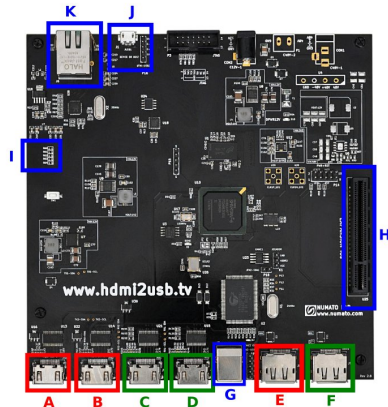
Future work

LKV373a Issues

- **HDMI extender works (usually)**
- **Hard to tweak stream parameters**
- **Sound is getting out of sync**
- **Unable to set compression params**
- **Stability issues**
- **The Black Box**

TimVideos - HDMI2USB

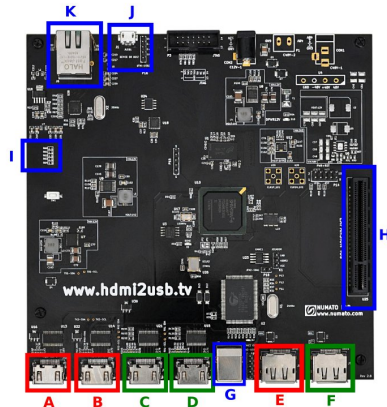
- OSS project for recording conferences
- Used for recording various events in Australia
- HDMI2USB[2]
 - Open Source
 - Open Hardware (Numato Ophis[7])
 - Multi input
 - Multi output
 - HDMI and DP grabber
- **Cost:**



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- **Cost:**

\$430



BTW - MiGen + LiteX

- **A Python toolbox[5] for building complex digital hardware**
- **Allows to program FPGA in Python**
- **Makes the code modular**
- **Makes the code really portable**
- **Makes the code really Open Source!**
- **Permissive two-clause BSD license**
- **LiteX[4] Cores Ecosystem**

TODO list

- **Get access to Numato board or any other dev board**
- **Reduce the FPGA bitstream:**
 - Only single HDMI input
 - Only Ethernet output
- **Find cheaper FPGA to handle this**
- **Redesign the board**



Summary

Summary

- **Creating a board farm is challenging**
- **Multi DUT vs Single DUT approach**
- **HDMI Extender can be useful for grabbing audio and video**
- **But it has some issues...**
- **Some collaboration with TimVideos could make a great result**
- **It's easy to simulate keyboard and mouse interaction**



Q & A

Thank you!

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References I

- [1] *danman's blog*. URL: <https://blog.danman.eu/new-version-of-lenkeng-hdmi-over-ip-extender-lkv373a/>.
- [2] *HDMI2USB Firmware*. URL: <https://github.com/timvideos/HDMI2USB-litex-firmware>.
- [3] Joonas Lahtinen. “Kernel Graphics Development on Remote Machines”. In: *FOSDEM 2018*. Brussels, 2018. URL: https://fosdem.org/2018/schedule/event/remote_kernel/.
- [4] *LiteX*. URL: <https://github.com/enjoy-digital/litex>.
- [5] *Migen*. URL: <https://github.com/m-labs/migen>.
- [6] *MuxPi wiki page*. URL: <https://wiki.tizen.org/MuxPi>.

References II

- [7] *Numato Opsis*. URL: <https://github.com/timvideos/HDMI2USB-numato-opsis-hardware>.
- [8] Krzysztof Opasiak. “Make your own USB device without pain and money!” In: *FOSDEM 2016*. Brussels, 2016. URL: <https://archive.fosdem.org/2016/schedule/event/makeyourownusbdevice/>.
- [9] Patrick Tatiano and Kevin Hilman. “Introducing the Lab in a Box Concept”. In: *Embedded Linux Conference Europe 2017*. Prague, 2017.
- [10] Neil Williams and Steve McIntyre. “VLANd in LAVA”. In: *Linaro Connect 2016 Bangkok*. Bangkok, 2016.